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10/697,106	10/31/2003	Yann Bodo	117653	9004

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ALEXANDRIA, VA 22320

EXAMINER	
KRASNIC, BERNARD	

ART UNIT	PAPER NUMBER
2624	

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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

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Office Action Summary	Application No. 10/697,106	Applicant(s) BODO ET AL.
	Examiner Bernard Krasnic	Art Unit 2624

-- *The MAILING DATE of this communication appears on the cover sheet with the correspondence address* --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *01 March 2007*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-18* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-18* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☒ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Response to Arguments

1. The amendment filed 3/01/2007 have been entered and made of record.

2. The Applicant has included newly added claim 18.

3. In response to the amendments filed on 3/01/2007:

The "Objections to the title, abstract and specification" have been entered and therefore the Examiner withdraws the objections.

The "Objections to the Drawings" have been entered and therefore the Examiner withdraws the objections to the drawings.

The "Objections to the claims" have been entered and therefore the Examiner withdraws the objections to the claims.

The "Claim rejections under 35 U.S.C. 112, second paragraph" have been entered and therefore the Examiner withdraws the rejections under 35 U.S.C. 112, second paragraph.

4. Applicant's arguments with respect to claims 1-18 have been considered but are moot in view of the new ground(s) of rejection by the Applicant's amendments toward independent claim 1.

The Applicant alleges, "I. Vynne Does Not Disclose a Reference Space Divided Into a Plurality of Predetermined Portions" in pages 9-10, "II. One of Ordinary Skill

Would Not Have Been Motivated to Combine Vynne with Han" in pages 10-11, and "III. The Asserted Combination of Vynne and Han Does Not Disclose or Suggest Two Complementary Zones" in pages 11-12, and states respectively that the reference Vynne discloses all the limitations of claim 1 as the Examiner discussed in the Examiners original Non-Final Office Action except that Vynne does not disclose a reference space divided into a plurality of predetermined portions. However, the Examiner disagrees; similarly the Examiner disagrees that there was no motivation to combine Vynne with Han; and similarly the Examiner disagrees that Vynne combined with Han does not disclose two complementary zones. Therefore the Examiner will maintain the rejections using the same references. Further discussions will be presented below and in the rejections below.

5. Applicant's arguments filed 3/01/2007 have been fully considered but they are not persuasive.

The Applicant alleges, "I. Vynne Does Not Disclose a Reference Space Divided Into a Plurality of Predetermined Portions" in pages 9-10, and states respectively that the reference Vynne discloses all the limitations of claim 1 as the Examiner discussed in the Examiners original Non-Final Office Action except that Vynne does not disclose marking the coordinates of the selected motion vector in a reference space divided into a plurality of predetermined portions. However the Examiner disagrees, the Examiner referring to the rejection for claim 1 in the Examiners original Non-Final Office Action states that the step of marking the coordinates of the selected motion vector (V) in a

reference space divided into a plurality of predetermined portions may be found in Vynne (see Fig. 3.1A, 3.2, col. 7, lines 43-51). The Examiners interpretation of Vynne was marking the coordinates / (xi,yi) of the selected motion vector (V) / subset U(n)V(n) [V(n)U(n) is the subset of a set of motion vectors V(n), where V(n)={v1, v2, ..., vn}, where vi=(xi,yi), and where xi and yi are the x and y coordinate of the motion vector vi] in a reference space / frame(n) (312, see Fig. 3.1A) divided into a plurality of predetermined portions / predetermined m number of blocks (310, see Fig. 3.1A). Therefore Vynne (see Fig. 3.1A, 3.2, col. 7, lines 43-51) does disclose the limitation of a marking of the coordinates of the selected motion vector in a reference space divided into a plurality of predetermined portions and therefore the Examiner maintains the rejection.

The Applicant alleges, "II. One of Ordinary Skill Would Not Have Been Motivated to Combine Vynne with Han" in pages 10-11, and states respectively that one of ordinary skill would not have been motivated to combine Vynne with Han. However the Examiner disagrees, because it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Vynne's motion vector blocks using Han's teachings by including the two complementary zones with hierarchical successive levels of motion vectors in order to optimize the encoding by using this multi-scale motion data represented by a tree to eliminate fine scale motion data (see Han, col. 1, lines 60-61, col. 2, lines 12-15). In response to applicant's argument that Han is nonanalogous art, it has been held that a prior art reference must either be in the field of applicant's endeavor or, if not, then be reasonably pertinent to the particular problem

with which the applicant was concerned, in order to be relied upon as a basis for rejection of the claimed invention. See *In re Oetiker*, 977 F.2d 1443, 24 USPQ2d 1443 (Fed. Cir. 1992). In this case, the motivation does exist to combine Vynne with Han because both relate to having blocks in frames with motion vector information.

The Applicant alleges, "III. The Asserted Combination of Vynne and Han Does Not Disclose or Suggest Two Complementary Zones" in pages 11-12, and states respectively that Han does not disclose or suggest defining two complementary zones Z0 and Z1 in each portion, one of the two zones being situated inside the other one and that there is no motivation to combine Vynne with Han. However, the Examiner disagrees, because Han does disclose two complementary zones Z0 (16, see Fig. 1) and Z1 / (the area between 16 and 18 [the area between 16 and 18 if you can consider is the area of 18 minus the area of 16], see Fig. 1) in each portion / area or block (18, see Fig. 1), one of the two zones being situated inside the other one (area 16 is situated inside the area between 16 and 18 [the area between 16 and 18 if you can consider is the area of 18 minus the area of 16]). Therefore Han does disclose the limitation of defining two complementary zones Z0 and Z1 in each portion, one of the two zones being situated inside the other one and therefore the Examiner maintains the rejection. As to the argument that there is no motivation to combine Vynne with Han, the discussions have been discussed above.

Claim Rejections - 35 USC § 103

6. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

7. Claims 1-18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Vynne et al (US 5,960,081) in view of Han et al (US, 6,845,130 B1).

Re Claim 1: Vynne discloses a method of watermarking / embedding a digital signature (217) (see Fig. 2.2, Abstract, lines 1-2) a video signal by applying a watermarking function to motion vectors calculated by estimation of movement (see col. 8, lines 1-9) between images of the video signal, the method comprising the following steps of applying the watermarking function to at least some of the calculated motion vectors (see Abstract, lines 4-6, col. 8, lines 1-3); and generating the watermarked video signal by compensating movement with the aid of the watermarked motion vectors (see Abstract, lines 1-6, col. 8, lines 1-3), the watermarking function being applied with the aid of a binary marking key (217, 219) (see Fig. 2.2, Abstract, lines 13-16, col. 7, lines 51-64, col. 12, lines 1-12), each bit of which is associated with at least one selected motion vector (Abstract, lines 13-16, col. 7, lines 51-64), to apply the watermarking function, the method further comprises the following steps of marking the coordinates / (xi,yi) of the selected motion vector (V) / subset U(n)V(n) [V(n)U(n) is the subset of a set of motion vectors V(n), where V(n)={v1, v2, ..., vn}, where vi=(xi,yi), and where xi and yi are the x and y coordinate of the motion vector vi] in a reference space / frame(n) (312,

see Fig. 3.1A) divided into a plurality of predetermined portions / predetermined m number of blocks (310, see Fig. 3.1A) (see Fig. 3.1A, 3.2, col. 7, lines 43-51); and if the coordinates / (xi,yi) of the selected motion vector / U(n)V(n) are in the zone of the portion to which it belongs, of binary value which corresponds to the bit of the marking key (217, 219, see Fig. 2.2) with which the selected motion vector is associated (see col. 7, lines 48-51), not modifying the coordinates of the selected motion vector (if not necessary, there will be no modifications of either the x or y-coordinate of the motion vectors according to bitset S(i) where S(i) represents the signature, col. 7, lines 48-51, col. 8, lines 1-3); if the coordinates (xi,yi) of the selected motion vector / U(n)V(n) are not in the zone of the portion to which it belongs, of binary value which corresponds to the bit of the marking key / (217, 219, see Fig. 2.2) with which the selected motion vector is associated , modifying the coordinates of the selected motion vector (if necessary, there will be modifications on either the x or y-coordinate of the motion vectors according to bitset S(i) where S(i) represents the signature, see col. 7, lines 48-51, col. 8, lines 1-3) so that it is in the zone, of binary value which corresponds to the bit of the marking key with which the selected motion vector is associated (see col. 7, lines 48-51).

However Vynne fails to disclose or fairly suggest defining two complementary zones Z0 and Z1 in each portion, one of the two zones being situated inside the other one.

Han discloses two complementary zones Z0 (16, see Fig. 1) and Z1 / (the area between 16 and 18 [the area between 16 and 18 if you can consider is the area of 18

minus the area of 16], see Fig. 1) in each portion / area or block (18, see Fig. 1), one of the two zones being situated inside the other one (area 16 is situated inside the area between 16 and 18 [the area between 16 and 18 if you can consider is the area of 18 minus the area of 16]), and assigning a binary value (taught by Vynne above) to each of the two zones.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Vynne's motion vector blocks using Han's teachings by including the two complementary zones with hierarchical successive levels of motion vectors in order to optimize the encoding by using this multi-scale motion data represented by a tree to eliminate fine scale motion data (see Han, col. 1, lines 60-61, col. 2, lines 12-15).

Re Claim 2: Han further discloses the reference space is a reference grid (14) including blocks / area or blocks (18) with predefined dimensions (see col. 1, lines 40-41), each block including first (the area 16) and second zones (the area between 16 and 18 [the area between 16 and 18 if you can consider is the area of 18 minus the area of 16]).

Re Claim 3: Han further discloses calculating a hierarchical plurality of successive levels (Level 0, Level 1, Level 2) of motion vectors (see Fig. 5, 6, col. 3, lines 45-47), the motion vectors of a given level each being associated with a plurality of motion vectors of the next lower level (see col. 3, lines 20-23); selecting at least some of the motion vectors belonging to the highest level (taught by Vynne above in claim 1); applying the

watermarking function to each selected motion vector, leading to calculating a modification parameter for said motion vector (taught by Vynne above in claim 1); and applying the modification parameter of the selected motion vector to the motion vectors of a lower level (it would have been obvious to one of ordinary skill in the art at the time the invention was made to have such a feature because of the fact that applying the modification to the lower levels would increase the difficulty of removing the embedded digital signature even further) associated with said motion vector.

Re Claim 4: Han further discloses the motion vectors of a given level are each equal to the average of the motion vectors of the next lower level (see Fig. 6, col. 3, lines 20-23) with which they are associated.

Re Claim 5: Han further discloses calculating a hierarchy of two successive levels of motion vectors, each motion vector of the higher level being associated with four motion vectors of the lower level (see Fig. 6, col. 3, lines 20-23).

Re Claim 6: Han further discloses the first (16, see Fig. 1) and second (the area between 16 and 18 [the area between 16 and 18 if you can consider is the area of 18 minus the area of 16], see Fig. 1) zones have substantially equal areas (see Fig. 1, the two zones 16 and the area between 16 and 18, have substantially equal areas as long as 18 is adjusted by the needed amount which it is capable of doing, col. 1, lines 40-41).

Re Claim 7: Han further discloses a sub-block (16) centered inside the block (18) is defined in each block of the reference grid (14), the first zone being defined by the interior of the sub-block (the area of 16) and the second zone (the area between 16 and 18 [the area between 16 and 18 if you can consider is the area of 18 minus the area of 16], see Fig. 1) being the zone in the block complementary to the first zone.

Re Claim 8: Han further discloses the blocks (18) and sub-blocks (16) of the reference grid (14) are rectangular (it would have been obvious to one of ordinary skill in the art at the time the invention was made to have such a feature because a rectangle is respectively a square as is seen in Fig. 1).

Re Claim 11: Vynne further discloses each bit of the binary marking key is associated with a plurality of selected motion vectors (see Fig. 2.2, Abstract, lines 13-15, col. 7, lines 41-59, col. 11, lines 50-67, col. 12, lines 1-12).

Re Claim 12: Vynne further disclose some of the bits of the binary marking key are associated with motion vectors calculated by motion estimation between two images of the video signal (see col. 7, lines 43-51), and wherein at least one other portion of the bits of the binary marking key is associated with motion vectors calculated by motion estimation between at least two other images of the video signal (col. 14, lines 60-63). Although Vynne fails to specifically disclose the limitation of using at least two other images for part of the binary marking key, it would have been obvious to one of ordinary

skill in the art at the time the invention was made to have such a feature because of the fact that it increases the difficulty of removing the embedded digital signature even further.

Re Claim 13: Vynne further discloses a device (210, 700, 710) for watermarking a video signal, the device (see Fig. 2.2, 7.1, col. 2, lines 12-22, see col. 10, lines 11-12) including means for implementing a method according to claim 1.

The limitation, as recited in claim 13, line 2, "means for implementing", invokes 35 USC 112, 6th paragraph.

Re Claim 14: Vynne further discloses a computer readable data medium (700, 710), including means for storing a video signal watermarked with the aid of a method according to claim 1 (see Fig. 7.1, col. 10, lines 11-12).

The limitation, as recited in claim 14, lines 1-2, "means for storing", invokes 35 USC 112, 6th paragraph.

Re Claim 15: Vynne further discloses a method of extracting watermarking (240) (see Fig. 2.3) from a video signal watermarked by applying a method according to claim 1, which extraction method comprises applying a function for extracting the binary marking key (228, 229) (see Fig. 2.3) comprising selecting the watermarked vectors (see col. 8, lines 10-13, Abstract, lines 13-16, col. 7, lines 51-64); marking the coordinates of each watermarked motion vector in the reference space (see col. 8, lines 10-13, Fig. 3.1A,

3.2, col. 7, lines 43-51); and assigning the binary value of the zone in which the watermarked vector is situated to the bit of the marking key with which the selected motion vector is associated (see col. 8, lines 10-13, Fig. 2.2, Abstract, lines 13-16, col. 7, lines 51-64, col. 12, lines 1-12). This claim is similar to claim 1 with the exception it is respectively opposite in that it is getting the embedded signature instead of actually embedding the signature (see Fig. 2.3, col. 8, lines 10-13).

Re Claim 16: Han further discloses calculating a hierarchical plurality of successive levels (Level 0, Level 1, Level 2) of motion vectors (see Fig. 5, 6, col. 3, lines 45-47), the motion vectors of a given level each being associated with a plurality of motion vectors of the next lower level (see col. 3, lines 20-23); selecting at least some of the motion vectors belonging to the highest level (taught by Vynne above in claim 1); applying the watermarking function to each selected motion vector, leading to calculating a modification parameter for said motion vector (taught by Vynne above in claim 1); and applying the modification parameter of the selected motion vector to the motion vectors of a lower level (it would have been obvious to one of ordinary skill in the art at the time the invention was made to have such a feature because of the fact that applying the modification to the lower levels would increase the difficulty of removing the embedded digital signature even further) associated with said motion vector; extracting the watermarked motion vectors associated with said motion vector (taught by Vynne above in claim 15); calculating an average vector equal to the average (see Fig. 6, col. 3, lines 20-23, respectively the same as in claim 4 with the exception that the average is taken

after the signature has been applied and removed) of the watermarked motion vectors associated with said motion vector; and applying the marking key extraction function to the calculated average vector (it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the marking key extraction function to the average vector instead of the vector taught by Vynne because of the fact that creating these average vectors would increase the difficulty of removing the embedded digital signature even further).

Re Claim 17: Vynne further discloses a device (700, 710) for extracting the watermarking from a video signal, including means (see Fig. 7.1, 10A, 10B, col. 8, lines 10-13, col. 10, lines 11-12) for implementing a method according to claim 15.

The limitation, as recited in claim 17, line 2, "means for implementing", invokes 35 USC 112, 6th paragraph.

Re Claims 9-10 and 18 respectively: Although Vynne and Han fail to specifically disclose the limitation of having a modification, if any, applied to the selected motion, vector (V) is a weighted symmetry, weighted central symmetry, or a weighted axial symmetry relative to one of the sides of the sub-block, it would have been obvious to one of ordinary skill in the art at the time the invention was made to have such a feature because of the fact that applying the modification as taught by Vynne (see col. 7, lines 48-51, col. 8, lines 1-3) in this type of weighted symmetric manner is much simpler and

it gives the ability to increase the difficulty of removing the embedded digital signature even further.

Conclusion

8. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. Kutter et al discloses a method for marking a compressed digital video signal; Dugelay discloses watermarking video, hierarchical embedding in motion vectors.

9. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

10. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Bernard Krasnic whose telephone number is (571) 270-1357. The examiner can normally be reached on Mon-Thur 8:00am-4:00pm and every other Friday 8:00am-3:00pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jingge Wu can be reached on (571) 272-7429. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Bernard Krasnic
May 8, 2007

JINGGE WU
SUPERVISORY PATENT EXAMINER

Notice of References Cited	Application/Control No. 10/697,106	Applicant(s)/Patent Under Reexamination BODO ET AL.	
	Examiner Bernard Krasnic	Art Unit 2624	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-6,785,332 B1	08-2004	Kutter et al.	375/240.16
	B	US-			
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	Dugelay, J. - "Watermarking video, hierarchical embedding in motion vectors" - IEEE - Sept. 2003, pages 739-742
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

WATERMARKING VIDEO, HIERARCHICAL EMBEDDING IN MOTION VECTORS

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1. ABSTRACT

This paper proposes a new video watermarking scheme based on a hierarchical motion analysis, that is robust against classical video processing (filtering, lossy compression...). This model works in the uncompressed domain and disturbs the motion vectors computed by an exhaustive BMA on blocks of size n*n in order to insert an invisible watermark enabling a protection against most attacks. Finally, to increase the robustness, our system inserts the mark by generating a hierarchy of motion vectors of size N*N with N=k*n to spread the mark on the lower level associated to block n*n.

2. INTRODUCTION

With the development of communication systems, in particular the growth of the internet with adsl and cable, the exchange of multimedia content between people has increased. In this context, it is necessary to be able to control the life of value multimedia content. Many systems have emerged over the last few years, like the cryptographic system. However it does not protect against unauthorized copying after the content has been successfully transmitted and decrypted. This is the kind of protection that can be handled by watermarking. A digital watermark is in fact a piece of information inserted and hidden in the media content. This information is imperceptible to a human observer but can be easily detected by a computer. Generally the secret is based on a key and there are no a posteriori protection (for example the css system for DVD [1] has not resisted for a long time). In this context, watermarking algorithms appear to be a complementary solution which allows full protection. The watermarking is well-suited for the protection of multimedia content. Its applications are various and numerous, they concern copyright application, fingerprinting, "smart content" application, etc. In [4], the authors propose a good introduction on the watermarking world and in [5], the authors present a good mathematical formalization of the watermarking problem. Until now, most of the video watermarking systems purposed are based on the extension of still image algorithms. However they suffer from a lack of robustness. Another way is to use the intrinsic notion of the video i.e. the temporal information. Consequently, we can classify video watermarking schemes in two main categories: Still image based techniques and video-adapted techniques. Finally, few papers focus their interest on marking dynamic areas.

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[1] http://www.dvd-copy.com/

Indeed, marking motion vectors has been first introduced by Kutter & al. in [2] in which the authors select a set of motion vectors over which they apply a parity rule to embed the mark. Zhang & al. in [8] used this principle to adapt the insertion rule by selecting the vector components that have the greatest magnitude. However, both methods suffer from serious drawbacks. Effectively a simple filter can destroy the parity of the motion vector components. In [6], the authors deal with marking motion vectors to be robust against transmission error on noisy and bandwidth limited channels. The goal of this article is not to protect media content but to provide better video quality. Thus the goal of this article consists in finding an insertion rule based on motion vectors able to resist to manipulation usually performed on video in real application (e.g. compression, filtering, etc.). Our system represents a semi-blind watermarking system. In fact, a marked vector must be maintained in a local space determined by the insertion rule to support attacks that will displace it around its initial position. This approach make it possible to resist filtering, compression and so on, that slightly displace marked motion vectors around their initial position. In section 3, we describe in detail our system by explaining the embedding and the retrieval processes. Then, in section 4 we present some results and we conclude in section 5.

3. TECHNICAL DESCRIPTION

A video stream is composed of a succession of still images. Thus, the watermarking of video sequences can be seen as an extension of image algorithm. One of the well-known techniques proposed in the video watermarking topic is the JAWS algorithm developed by T. Kalker & al.[3]. JAWS is based on simple operations allowing you to reach the real time requirement and in which the video is considered as a succession of still images. It is possible to watermark only the intra images of video sequence, that could explain the great number of watermarking scheme developed for still image adapted to video.

Nowadays, literature has only provided few watermarking algorithms that consider temporal information as a key advantage. Nor propose robust solution. Indeed, it seems natural to consider that the robustness of a mark can be greatly improved by considering the following two video properties:

- information amount (a video denotes a larger information than still images);
- motion information.

However, the insertion of the mark is also constrained by time complexity, compression constraints and new class of attacks such as collusion [1].

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We can classify the video watermarking schemes into 2 main categories, still image adapted techniques and video adapted techniques. Our scheme belongs to the second one.

3.1. Embedding

The main functionality of our watermark algorithm consists in providing robust authentication of a Copyright Owner. The copyright information, composed by 8 bits, carried by the watermark could be generated by a secret key owned by the copyright owner. Thus this information could be inserted in the video by using a psycho-visual mask or a pseudo-random process. In this paper, only the rule insertion of that watermark is described, a lot of preprocessing of the mark, like error correcting code or cryptographic technique could be added to robustify the process. In fact, an exhaustive BMA estimation is applied to block n*n, with n=4. Thus, we determine a hierarchical motion vectors pyramid by averaging the fourth vectors associated to the four concatenated blocks B_1, B_2, B_3, B_4 as explained in the Figure 1. The motion vector associated to the block8x8 represents the father block in our approach. Thus, the insertion rule is applied on the averaged motion vectors associated to the blocks 8*8.

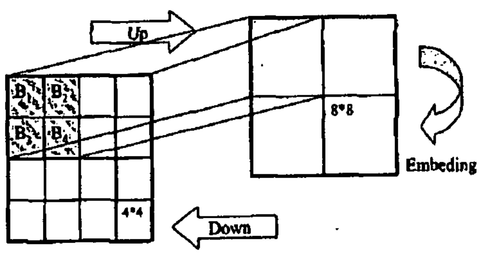

Fig. 1. Hierarchical scheme

For this, we select a subset of motion vectors to be marked. Today, this selection is a determinist one, however to improve the robustness of this approach and to minimize the visibility of the mark, we could use a pseudo-random selection or an adaptive selection based on a psycho-visual mask. In this approach, the embedding rule is defined by:

$$\forall \vec{d_f} = (d_f^x, d_f^y)^T \in \widetilde{V}_f, d_f^W = \vec{d_f} + \widetilde{\Phi}(\alpha, \sigma_f(W), K_{\sigma_f(W)}) \quad (1)$$

where:

$$\widetilde{\Phi}(\alpha, \sigma_f(W), K_{\sigma_f(W)}) = \alpha \times \Upsilon(\sigma_f(W), K_{\sigma_f(W)}) \quad (2)$$

where $\widetilde{\Phi}$ and Υ are non reversible functions. To improve the robustness of this approach, the insertion rule must respect a spatial structure based on the construction of a reference grid $\mathcal{G}$ as illustrated on Figure 2. This rectangular grid is generated in the Cartesian space and is associated to a referential $(O, \vec{i}, \vec{j})$. It represents a block-based partitioning of the image compact support resulting in a set of block elements E, each of size $H \times K$ (in the case presented in this paper, $H = K = 7$). Let us denote by R_i the intersection points between blocks that we call *reference points*.

Each selected motion vector of $\widetilde{V}_f$ is first projected on $\mathcal{G}$ and

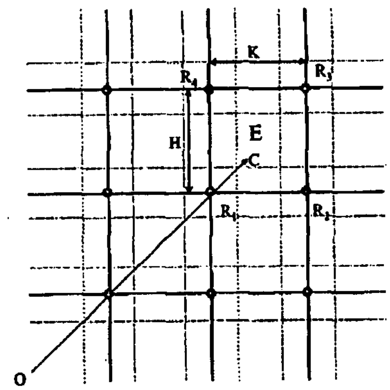

Fig. 2. Construction of a reference grid to embed a watermark on motion vectors

this projection serves to compute its associated reference point. The Figure 2 illustrates this process: the extremity of the projected motion vector $\vec{OC}$ belongs to a block E of $\mathcal{G}$ from which four intersection points R_1, R_2, R_3 and R_4 can be deduced. The reference point of the motion vector is the one which is the nearest to the extremity of the vector according to the L^2 distance. In the example of the Figure 2, the reference point of $\vec{d_f}$ is R_1.
Then, to embed the mark, the motion vector is modified (see Figure 3) by constructing in each block element E a rectangular element of size $h \times k$ (area Z_1), where $h = H - \delta_1$ and $k = K - \delta_2$ and δ_1 and δ_2 are chosen in order to have the same area covered by Z_1 and Z_2 and with $Z_1 \cup Z_2 = E$ (in the case presented here, $\delta_1 = \delta_2 = 1$). These two zones Z_1 and Z_2 drive the mark embedding rule: Z_1 is associated to the bit -1 and Z_2 to the bit $+1$.

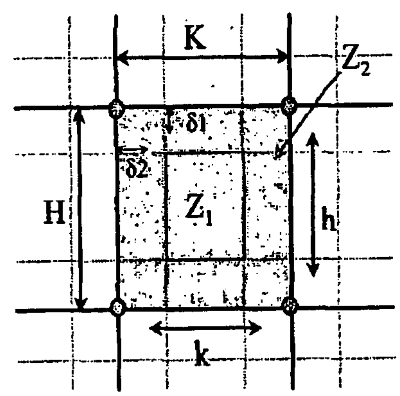

Fig. 3. Block element partitioning to embed the mark

Then, if we consider that $\vec{d_f} = \vec{OC}$ is the vector to be marked and W_i is the bit to be inserted, the marked vector d_f^W is computed

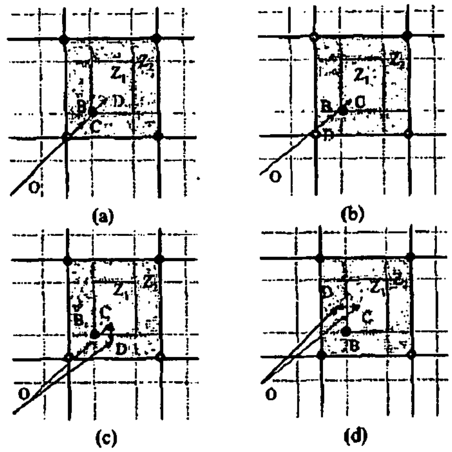

Fig. 4. Computation of the marked vector

as follows:

- if $W_i = -1$ and if $\vec{d_f}$ is in the right place (i.e. in the zone Z_1) then $d_f^{\vec{W}} = \vec{d_f}$; otherwise, a central symmetry of center B must be applied resulting in $d_f^{\vec{W}} = \overrightarrow{OD}$ (cf. Figure 4(a));
- if $W_i = +1$ and if $\vec{d_f}$ is in the right place (i.e. in the zone Z_2) then $d_f^{\vec{W}} = \vec{d_f}$; otherwise, as the Z_2 area is not compact, three possibilities can appear to compute $d_f^{\vec{W}}$:
  - $d_f^{\vec{W}}$ is given by a central symmetry of center B (cf. Figure 4(b));
  - $d_f^{\vec{W}}$ is given by an axial symmetry parallel to the y axis and going through B (cf. Figure 4(c));
  - $d_f^{\vec{W}}$ is given by an axial symmetry parallel to x axis and going through B (cf. Figure 4(d)).

The choice of symmetry must minimize the distortion of $\vec{d_f}$. In fact, after computing $d_x = C_x - B_x$ and $d_y = C_y - B_y$ (with $B = (B_x, B_y)^T$ and $C = (C_x, C_y)^T$), the symmetry is chosen as follows:

- if $d_x \leq \delta_2$ and $d_y \leq \delta_1$, the central symmetry is applied;
- if $d_x \leq \delta_2$ the axial symmetry parallel to the x axis is applied;
- if $d_y \leq \delta_1$, the axial symmetry parallel to the y axis is applied.

The modification realized on the highest level is then applied to the lowest level (down step). This approach allows us to create redundancy in the insertion phase, the watermarking scheme is consequently more robust. We realize a hierarchic spreading of the mark. To end, we perform a motion compensation. This step can be either performed on all of the blocks or either only on marked blocks and completed by original blocks. The second approach make it possible to avoid artifacts generated by only exploiting motion estimator, and in the same time increased the robustness of the detection process.

3.2. Retrieval process

The retrieval process correspond to the dual of the embedding process. Thus to detect the mark, we only had to apply algorithm1.

Algorithm 1 Mark detection algorithm

> **for** f= 1 **to** N { //N denotes the video frame number
> **for** i = 1 **to** k_f {
> **if** $\vec{d_f^i} \in Z_1$ **then** $\sigma_f^i(W) = -1$;
> else if $\vec{d_f^i} \in Z_2$ **then** $\sigma_f^i(W) = +1$;}}

Once a candidate mark $\widetilde{W}$ is detected by the Algorithm 1, we must decide if it corresponds to the real embedded mark W. For this purpose, we compute the correlation C_f at frame f between $\widetilde{W}$ and W by the following recursion:

$$C_f = \frac{C_{f-1} \times (f-1) + (1 - \frac{d(\widetilde{W}, W)}{N})}{L} \quad (3)$$

where L denotes the number of marked frames, $d(\widetilde{W}, W)$ denotes the Hamming distance between $\widetilde{W}$ and W and N is the mark length.

If $C_f \geq \theta$, where θ is a pre-defined correlation threshold, $\widetilde{W}$ is considered to correspond to W.

4. RESULTS

The above watermarking system has been tested on various video. In this section, we give some results obtained on the well-known sequences "stefan" (250 frames) and "ping-pong" (250 frames). These sequences are in the YUV format and their size are 288*352 (CIF format). We have conducted some experiments to check the robustness of our proposed watermarking scheme. For this purpose, we have performed some of the classical sequence manipulations including Divx[2] lossy compression, blurring with a uniform kernel and rotation. Additionally, we also have controlled the robustness of our algorithm to the new codec that appears nowadays, namely H264 [7]. The H264 retained model was IBP with quantization steps of 10 and 20. Moreover, all optimization parameters (eighth pixel motion estimation, five reference images, etc.) have been used. The compression ratio used for the sequence "stefan" ("ping-pong" respectively) was 1:60 (1:60) for the Divx codec, 1:28 (1:40) for H264 IBP10 and 1:123 (1:154) for H264 IBP20. We have not tested the algorithm against frame dropping and rate changes yet.

The correlation results obtained with these attacks on the "stefan" sequence are plotted on Figure 5 and on Figure 6 for the "ping-pong" sequence. Let us recall that the correlation level for a frame index f tells us if the mark has been detected in f. On this figure, the correlation threshold θ has been set to $\theta = 0.875$. The average PSNR for the sequence "stefan" is $43.7db$ and for the sequence "ping-pong" is $44.9db$. These results show that the mark is quickly detected whatever the transform applied onto the sequence. The results obtained on the sequence "ping-pong" are slightly worst than for the sequence "stefan". Indeed, we can note that for the Divx compression and for the "IBP20" compression the threshold is not reached, but the curves seems to converge to the right

[2] http://www.divx.com/

mark. By analyzing these results, we can conclude that our watermark process is particularly robust to all tested attacks and few sequence images are needed to detect the embedded mark.

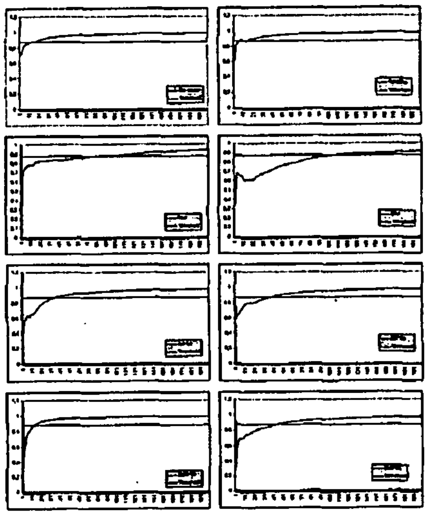

Fig. 5. Correlation results on the "stefan" sequence

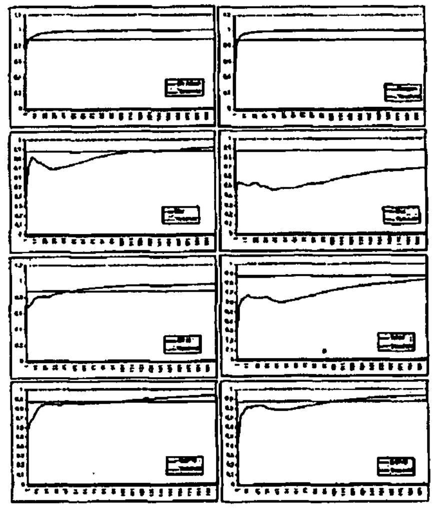

Fig. 6. Correlation results on the "ping-Pong" sequence

5. CONCLUSION

In this paper, we have presented a new video watermarking algorithm that is robust to classical attacks. Effectively, preliminary experiments have shown the effectiveness of this algorithm. This approach allows us to exploit the notion of temporal axis, by inserting a watermark on motion vectors. The chosen insertion rule has proven that we are able to increase the algorithm robustness. In order to validate our approach, more tests must be done on various sequences and other attacks. Future works will deal with improving the detection criteria in order to reach more flexibility. Indeed sometimes the detector converges to the right mark but the correlation score does not reach the threshold fast enough. Finally, some improvements concerning the robustness had to be done as pretreatment on the mark (like cryptography rules or by using error correcting codes). Moreover due to the determinist approach, we actually have some visible artifacts on a few videos, thus currently we are working on HVS (Human Visual System mask) to exclude them.

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